Appendix C

TRE Case Study:
City of Reidsville, North Carolina

Abstract

TRE Goal:	NOEC >90%
Test Organism:	*C. dubia*
TRE Elements:	TIE and Toxicity Tracking Assessment (RTA)
Toxicant Identified:	Surfactants
Toxicity Controls:	Pretreatment requirements

Summary

The TRE study used a novel approach to identify the sources of POTW effluent toxicity. Subsequent modifications in chemical usage by industrial contributors successfully reduced effluent toxicity to the NOEC limit in 1994. Further studies are in progress to ensure consistent compliance with the toxicity limit.

Key Elements

1. Other TRE procedures can be used if the TIE cannot identify the effluent toxicants. One such procedure uses a toxicity-based tracking approach to locate the sources of toxicity in municipal collection systems.
2. The toxicity-based tracking approach, referred to as the RTA procedure, can be adapted to fit the site-specific conditions at each POTW.
3. Once identified, the toxic contributors can be required through the industrial pretreatment program to reduce the discharge of toxicity. Practical control techniques are available to industries, including substitution of toxic chemicals, waste minimization, and pollution prevention.

Introduction

The City of Reidsville was required by the North Carolina Division of Environmental Management (NCDEM) to conduct a TRE based on evidence of chronic effluent toxicity at its POTW. Monthly NOECs for *C. dubia* have averaged about 35% effluent since 1992. These values show that chronic effluent toxicity has consistently exceeded the discharge permit NOEC limit of 90% effluent.

Background

In 1992, the City submitted a TRE plan and initiated TIE studies to determine the cause(s) of the effluent toxicity. Chronic TIE Phase I (Tier I) tests indicated that surfactants were the principal toxicant group. This evidence was based on toxicity reduction by filtration, aeration, and C18 SPE in the Phase I tests. TIE Phase II tests were performed to try to identify the toxic surfactant compounds; however, the results were inconclusive because of the difficulty in isolating the toxicants and the lack of conventional analytical techniques for surfactant compounds. The toxicants removed by the C18 SPE column were recovered by eluting the column with methanol, but toxic compounds could not be identified in the column extract (Burlington Research Inc., 1993).

In cases where the TIE is not successful in identifying the effluent toxicants, other TRE steps can be used to gather information on the nature and sources of effluent toxicity. USEPA and several municipalities have worked together in USEPA funded studies to develop the RTA method, which can be used to assess the potential toxicity contribution from indirect dischargers in sewerage collection systems (USEPA, 1989a; Botts et al., 1987; Morris et al., 1991; Fillmore et al., 1990; Collins et al., 1991). The RTA procedure involves treating industrial wastewater samples in a bench-scale, batch simulation of the POTW, and measuring the resulting toxicity. The toxicity remaining after batch treatment, referred to as refractory toxicity, represents the toxicity that passes through the POTW and is discharged in the effluent. Several municipalities have successfully used the RTA procedure to identify industrial sources of toxicity (Botts et al., 1992; Morris et al., 1991; and Engineering-Science, Inc., 1992).

Description of Treatment Plant

The major treatment processes at the Reidsville POTW are extended activated sludge treatment and filtration. Influent wastewater, which averages 2.8 mgd, is initially screened and then treated in two activated sludge aeration basins equipped with mechanical surface aerators. Both carbonaceous BOD and ammonia are removed in this single-stage aeration system. After 48 hours contact time, the basin effluent flows to the final clarifiers for solids clarification. The clarified effluent is then passed through sand filters to remove remaining suspended solids that may contribute to effluent BOD. The filter effluent is disinfected with chlorine gas and dechlorinated and aerated prior to discharge. Waste activated sludge is thickened and aerobically digested for land application.

Refractory Toxicity Assessment Procedure

Selection of Industries for Testing

Acute and chronic toxicity tests were performed on raw wastewater from the seven permitted significant industrial users in the Reidsville collection system. The industrial wastewater samples were tested at concentrations that reflected the average flow contribution of the industries to the POTW (dilutions were made with reconstituted lab water).

The results showed that five of the seven industries were contributing chronic toxicity to the POTW (Table C-1). It is possible that at least some of the raw wastewater toxicity would be removed by treatment at the POTW; therefore, the five toxic industrial users were selected for further evaluation by RTA testing. A description of the industries evaluated in the RTA is provided in Table C-2.

Test Procedure

A step-by-step description of the RTA procedure is given in Section 5 and Appendix J. The generic procedure must be adapted to simulate the treatment processes and operating conditions at each POTW. Several types of treatment processes can be simulated, including conventional activated sludge systems (Botts et al., 1987; Morris et al., 1991; and Fillmore et al., 1990), single and two-stage nitrification processes (Collins et al., 1991), and BNR systems (Botts et al., 1992).

The RTA simulated the two main treatment processes at the Reidsville POTW: the activated sludge and sand filtration processes. Wastewater samples were first treated in biological reactors and then the clarified effluents were passed through a bench-scale sand filter column.

Table C-1. Chronic Toxicity of Raw Industrial Wastewaters

Industry	*C. dubia* Chronic Pass/Fail Result*			
	May 1992	June 1992	July 1992	April 1993
A	Fail	Fail	Fail	Fail
B	Fail	NT†	Fail	Fail
C	Fail	Fail	Fail	Fail
D	Fail	NT	Fail	Fail
E	Pass	Pass	Fail	Fail
F	Pass	Pass	Pass	NT
G	Pass	Pass	Pass	NT

* Tests were conducted using industrial wastewater diluted according to its percent contribution to the total POTW influent.
† NT = Not tested.

Table C-2. Description of Industries Evaluated in the RTA

Industry	Type	Flow (mgd)	%Flow* to POTW
A	Textile	1.072	65
B	Tobacco Products	0.308	28
C	Can Making	0.085	10
D	Food Processing	0.189	12
E	Metal Finishing	0.031	2
Domestic			38

* Based on maximum industrial flow and minimum POTW influent flow, except for domestic, which is based on average flow and minimum POTW influent flow.

Two types of simulations were tested as shown in Figure 5-2 (see Section 5). A control simulated the existing treatment conditions and treated only the POTW influent. The second simulation evaluated the addition of the industrial discharge to the POTW and treated the industrial wastewater spiked into the POTW influent.

The amount of industrial wastewater spike represented the conservative condition of maximum industrial flow and minimum total influent flow at the POTW. The operating conditions for the simulations are described in Table C-3.

Table C-3. Comparison of Operating Conditions for the City of Reidsville POTW Processes and RTA Simulation Tests

POTW Process Specifications	Treatment Plant	RTA Simulation
Activated Sludge Process		
Mixed liquor solids (mg/L)	2,200–2,500	2,240–2,740
DO (mg/L)	>2	2.4–9.2
Treatment period (hours)	48	48
Sand Filter Process		
Filtration rate (gpm/sf)	0.8	0.8
Total filter area (sf)	2,520	0.09
Sand particle size (mm)	0.45	0.45
Sand depth (inches)	10	10
Water depth on filter (ft)	0–7	0.1–2.5
Backwash rate (gpm/sf)	12	5 (estimated)

The results of the control and spiked simulations are compared to determine whether addition of the industrial wastewater increases effluent toxicity. An industry would be considered a source of toxicity if the effluent of the spiked simulation is more toxic than the control effluent.

Sampling

Three rounds of RTA tests were performed over a 4-month period. Twenty-four hour composite samples of the industrial wastewaters, POTW influent, domestic wastewater, and POTW effluent were collected for testing. In addition, a grab sample of the POTW RAS was collected on the day of testing. Domestic wastewater was tested because TRE studies at other municipalities have shown that domestic sources can contribute to effluent toxicity (Botts et al., 1990). The POTW effluent served as a baseline for comparison with the RTA control to determine if the treatment performance of the simulations and the POTW were similar.

Toxicity Monitoring

Following biological treatment, the clarified reactor effluents were passed through the sand filter column and the resulting filtrates were tested for chronic toxicity using *C. dubia*, the test species specified in the NPDES permit. Each RTA effluent sample was used for both test initiation and renewals on days 3 and 5 of the toxicity test (USEPA, 1989b).

Results

Source Characterization

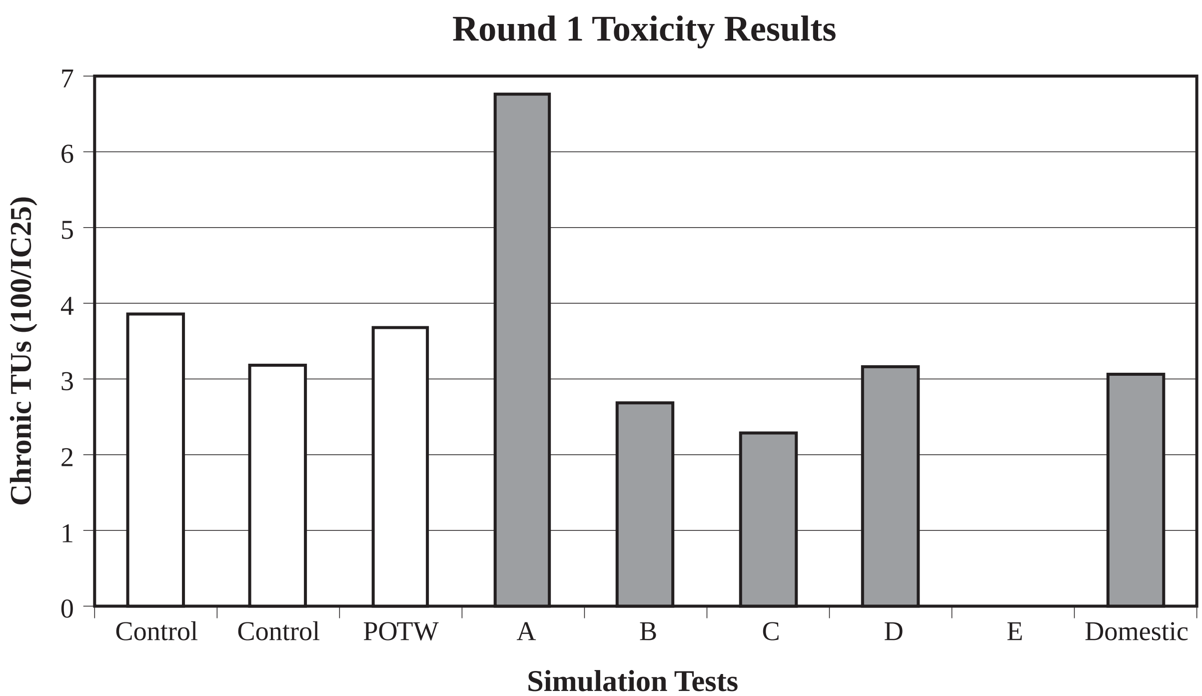
Two rounds of RTA tests were used to characterize the sources of toxicity. As shown in Figure C-1, the effluent TUc for the two control simulation tests in Round 1 were 3.8 and 3.1. These values compare well with the POTW effluent (TUc =3.6). The control simulation effluents in Round 2 also exhibited similar toxicity (TUc =3.0 and 2.9) as the POTW effluent (TUc =3.4). These results indicate that the RTA test accurately simulated the POTW with respect to toxicity treatment.

As shown in Figure C-1, the effluent from the simulation spiked with Industry A wastewater was about twice as toxic (TUc=6.7) as the control effluents in both rounds of tests. Effluent TUc values for the simulations spiked with other industrial wastewaters were similar to or less than the effluent TUc for the controls.

The results of both rounds of testing indicate a potential for Industry A to contribute toxicity to the POTW. The results for the simulations spiked with the other industrial wastewaters suggest that Industries B, C, D, and E do not contribute measurable toxicity to the POTW.

Toxicity Confirmation

A recent study for a New Jersey municipality found that an industry was contributing toxicity in amounts



Note: Industry E was not tested in round 1.

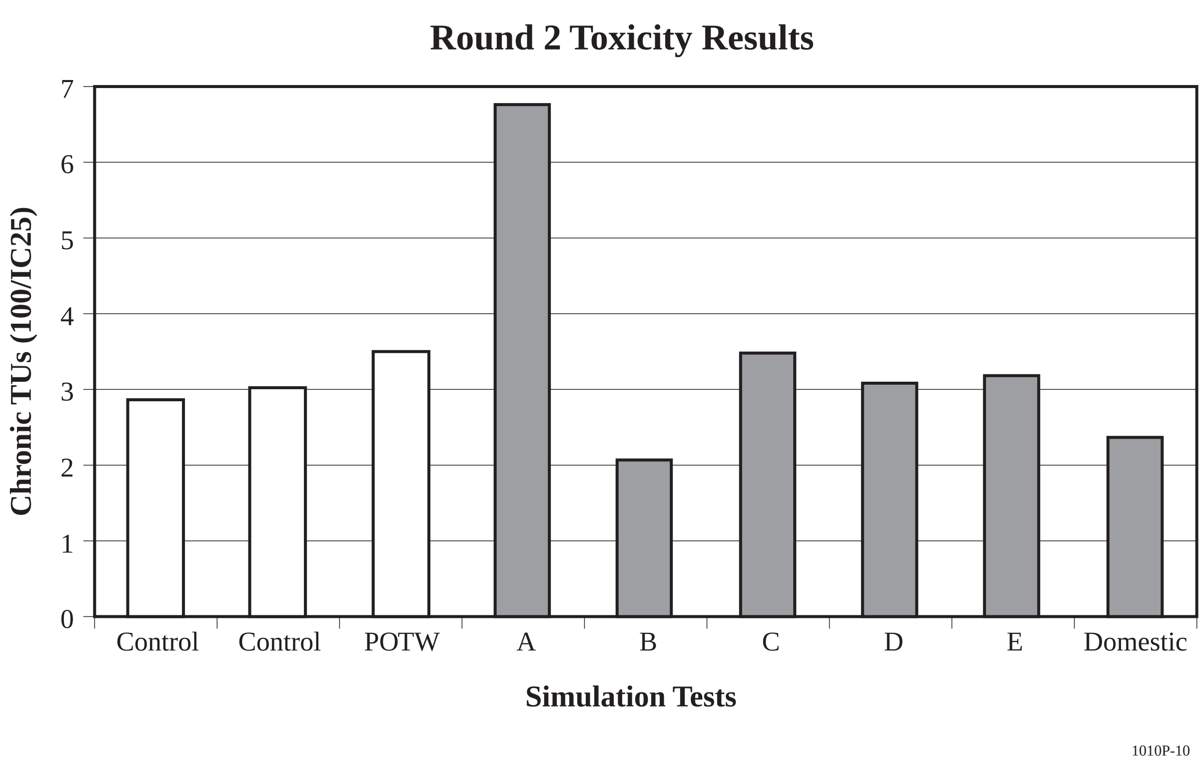


Figure C-1. Results of RTA (rounds 1 and 2).

high enough to mask other smaller sources of toxicity (Morris et al., 1991). It was necessary to remove the larger source of toxicity from the RTA test regime before other significant sources could be identified. The City of Reidsville decided to conduct a third round of tests to determine if a similar situation was occurring at their POTW.

Round 3 involved using a mock influent that did not contain Industry A wastewater. The mock influent was used in lieu of the POTW influent for the controls and the spiked simulations. The mock influent consisted of samples collected from each major sewer line with the exception of the sewer receiving Industry A wastewater.

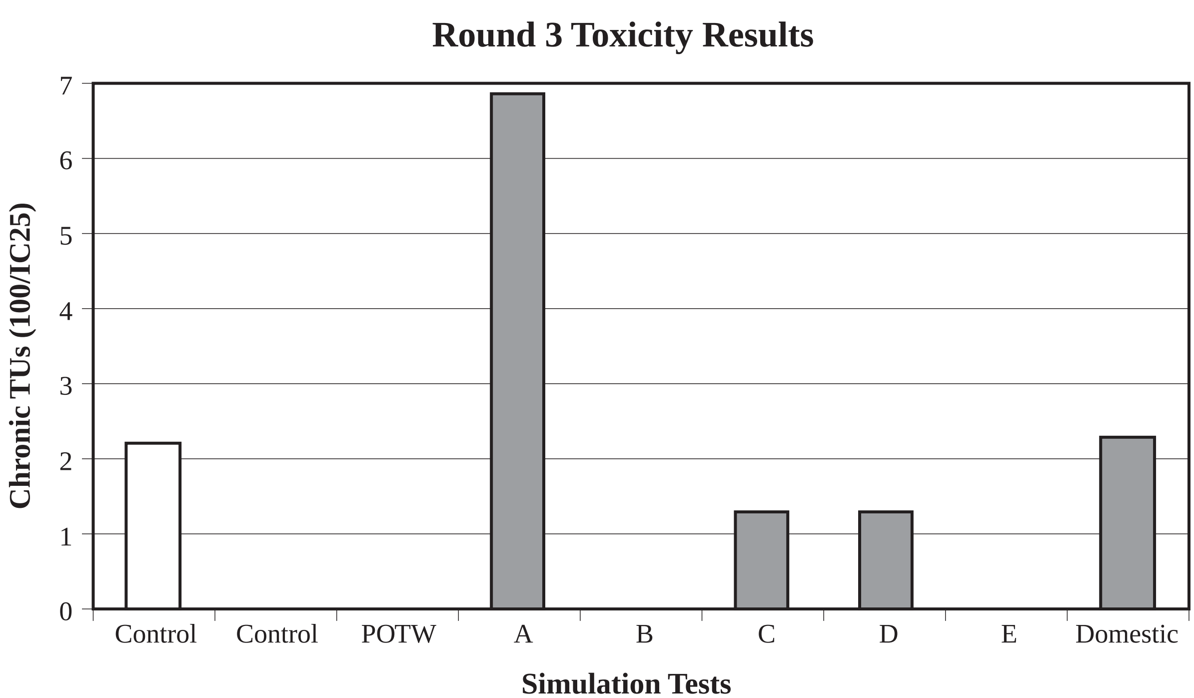
Toxicity results for the RTA simulation effluents are presented in Figure C-2. A comparison of results shows that the effluent of the Industry A spiked simulation was several times more toxic (TUc=6.8) than the control effluent (TUc =1.2). These results provide further evidence that Industry A is a source of toxicity. The simulations spiked with Industry C and D wastewater had similar effluent toxicity (TUc=1.3 for both) compared to the control. These data indicate that Industries C and D are not contributing significant toxicity to the POTW.

The simulation spiked with domestic wastewater had greater effluent toxicity (TUc=2.3) than the control (TUc=1.2). These results suggest that this waste stream may be a source of toxicity; however, results of Round 1 and 2 indicate that domestic wastewater collected from other areas of the collection system is not a problem. Further studies are planned to evaluate the potential toxicity contribution from domestic sources throughout the collection system.

Discussion

The results of this study indicate that Industry A is a major contributor to chronic effluent toxicity at the Reidsville POTW. None of the other industries (B, C, D, and E) were found to discharge measurable toxicity even after the potential toxicity interference from Industry A was removed.

In January 1994, the City of Reidsville implemented a program to minimize or eliminate the discharge of industrial chemicals that may contribute to the POTW effluent toxicity. Although the RTA results indicated



Note: A replicate control and POTW effluent were not tested in round 3. Industries B and E were not indicated to be sources of toxicity in rounds 1 and 2; therefore, these industries were not tested in round 3.

1010P-11

Figure C-2. Results of RTA (round 3).

that Industry A is the major contributor of chronic toxicity, all of the City's eight permitted industrial users were requested to participate. The program involved:

- An evaluation of current chemical usage and the selection of alternative materials of low toxicity, low inhibition potential, and high biodegradability.
- An on-site evaluation of waste-minimization practices by the North Carolina Office of Waste Reduction.

Particular attention was given to surfactant products or chemicals with surfactant constituents because the TIE had indicated surfactants to be the principal toxicant in the POTW effluent. Industries were requested to maintain chronological records of changes in chemical usage, production, and housekeeping practices. These records were used to compare the timeline of industry modifications to results of chronic toxicity monitoring at the POTW.

Follow-up monitoring results showed a substantial reduction in effluent toxicity. Beginning in March 1994, the IC25 values (an endpoint that approximates the NOEC) for 7 of 10 monthly *C. dubia* toxicity tests were $\geq$90%. A review of the industries' chronological records established a correlation between toxicity reduction and chemical optimization practices, especially those implemented at Industry A.

However, in 1995 occasional chronic effluent toxicity was again observed. Since early 1997, the effluent has exhibited consistent chronic toxicity (NOEC=30–45%). Current studies are focusing on treatment with polymer, which has shown to reduce toxicity in bench-scale tests. The City is also working with the industries to implement additional chemical optimization and waste minimization practices. In addition, construction is underway to extend the outfall from a small creek to a river, which will afford greater dilution. In 1998, the City will need to meet a revised chronic toxicity limit of an NOEC of approximately 61%.

Summary

The RTA protocol was initially developed as part of TRE research studies funded by the USEPA Risk Reduction Engineering Laboratory in Cincinnati, Ohio. The procedure was intended to be used by municipalities as a tool for tracking sources of toxicity in sewer collection systems; however, the RTA approach has evolved to suit other purposes. In addition to toxicity tracking (Collins et al., 1991), the RTA protocol has been used to determine the compatibility of planned discharges to POTWs (Engineering-Science, Inc., 1992, 1993) and to establish compliance with toxicity-based pretreatment limits (Morris et al., 1991).

Acknowledgments

Burlington Research, Inc. (Burlington, North Carolina) and Engineering-Science, Inc. (Fairfax, Virginia), conducted the TRE study. Burlington Research, Inc., performed the TIE tests, with assistance by EA Engineering, Science and Technology, Inc. (Sparks, Maryland), and the evaluation of industrial chemical usage. Engineering-Science, Inc., performed the RTA study. Burlington Research, Inc., and Engineering-Science, Inc., acknowledges Mr. Jerry Rothrock (Director of Public Works, City of Reidsville), and Donald Waddell, Lisa Haynes, Mitzy Webb, and James Fain (Hydro Management Services) for their assistance.

The material presented in this appendix includes copyrighted data presented in a technical paper for the 67th Annual Water Environment Federation Conference (Botts et al., 1994). WEF has granted permission to include the data in this document.

References

Botts, J.A., J.W. Braswell, E.C. Sullivan, W.L. Goodfellow, B.D. Sklar, and A.G. McDearmon. 1987. *Toxicity Reduction Evaluation at the Patapsco Wastewater Treatment Plant.* Risk Reduction Engineering Laboratory, Cincinnati, Ohio. Cooperative Agreement No. CR812790-01-1. NTIS # PB 88-220 488/AS.

Botts, J.A., L.B. Fillmore, E.J. Durhan, W.A. Goodfellow, T. Pereira, and D.F. Bishop. 1990. Evaluation of the Role of Diazinon in the Toxicity of a Municipal Wastewater Treatment Plant Effluent. *Proceedings of the Third National Pesticide Conference,* November, 1990, Richmond, Virginia.

Botts, J.A., T.L. Morris, J.E. Rumbo, and C.H. Victoria-Rueda. 1992. "Case Studies - Municipalities." In *Toxicity Reduction: Evaluation and Control.* D.L. Ford, ed. Technomic Publishing Co., Lancaster, Pennsylvania.

Botts, J.A., T. Schmitt, E. Wilson, M. Collins, D. Waddell, R. Diehl, and L. Ehrlich. 1994. Refractory Toxicity Assessment: An Alternative Approach for Chronic Toxicity Reduction Evaluations. Technical paper presented at the *Annual Conference and Exposition of the Water Environment Federation*, Chicago, Illinois. Paper #AC944404.

Burlington Research, Inc. 1993. *Toxicity Reduction Evaluation: City of Reidsville, Phase I/II Report.* Burlington, North Carolina.

Collins, M.A., T.L. Morris, J.A. Botts, T. Norberg-King, J. Thompson, and D.I. Mount. 1991. *Chronic Toxicity Reduction Evaluation Study at the Bergen County Utilities Authority Wastewater Treatment Plant*. Draft Report, 1991. USEPA, Risk Reduction Engineering Laboratory, Cincinnati, Ohio. USEPA Contract No. 68-03-3431.

Engineering-Science, Inc. 1992. *Results of the Refractory Toxicity Assessment for an Auto Parts Manufacturer*. Prepared by Engineering-Science, Fairfax, Virginia.

Engineering-Science, Inc. 1993. *Results of the Refractory Toxicity Assessment for a Store Fixtures Manufacturer*. Prepared by Engineering-Science, Fairfax, Virginia.

Fillmore, L.B., T.L. Morris, T.L. Champlin, M.C. Welch, and J.A. Botts. 1990. *Toxicity Reduction Evaluation at the City of Fayetteville Cross Creek Wastewater Treatment Plant*. Draft Report, 1990. USEPA, Risk Reduction Engineering Laboratory, Cincinnati, Ohio. USEPA Contract No. 68-03-3431.

Morris, T.L., G. Fare, and J. Spadone. 1991. *Toxicity Reduction Evaluation at the Linden Roselle Sewerage Authority Wastewater Treatment Plant*. Presented at the 64th Water Pollution Control Federation Conference, Toronto, Ontario, October 7-10, 1991. #AC91-055-001.

USEPA. 1989a. *Toxicity Reduction Evaluation Protocol for Municipal Wastewater Treatment Plants*. EPA/600/2-88/062. Risk Reduction Engineering Laboratory, Cincinnati, Ohio.

USEPA. 1989b. *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms*. EPA/600/4-89/001. Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

USEPA. 1991b. *Technical Support Document for Water Quality-Based Toxics Control*. EPA/505/2-90/001. Office of Water, Washington, D.C.